REMARKS

Reconsideration and allowance are respectfully requested in light of the above amendments and the following remarks.

Claims 1-23 remain pending in the application. Of these, claims 7-10 and 19 are withdrawn from consideration and claims 1 and 3 have been amended herein.

Claims 1-6, 11-18, and 20-23 stand rejected under 35 USC §103(a) as being unpatentable over Tanaka et al. (US 6,377,596) in view of Tokunaga et al. (US 5,425,808) and Nakamura et al. (JP 01-234389A). Applicant respectfully traverses these rejections.

Claim 1 now recites:

> *A method for forming a single crystalline film comprising the steps of:*
> *forming an amorphous film on a single crystalline substrate,*
> *forming an opening in the amorphous film and thereby exposing a part of a surface of the substrate, and*
> *introducing atomic beams, molecular beams or chemical beams onto the surface of the substrate at their incident angle of not more than 40 degrees with respect to the substrate surface under a reduced atmosphere and thereby selectively and epitaxially growing a single crystalline film on the exposed surface of the substrate without excitation of the substrate surface.*

Citing Tokunaga's disclosed examples, the Advisory Action states that Tokunaga teaches epitaxial growth that is not limited to growing the same kind of material as the substrate (Advisory Action, page 2). However, Tokunaga's examples do not teach

epitaxially growing a different kind of single crystalline film directly on a single crystalline substrate within an opening formed in a photoresist film 11 or an Al_2O_3 film 16. Instead, Tokunaga discloses in examples 1 and 3 that an opening is implanted with As ions, and thus, excited. Thereafter, a GaAs film is grown within the excited opening. In example 2, Tokunaga discloses employing an Al_2O_3 film as a nucleus layer. Thus, the desired GaAs film is grown on the Al_2O_3 film, not within an opening formed in the Al_2O_3 film.

Therefore, Tokunaga only teaches growing a single crystalline film directly on a single crystalline substrate, within a non-excited opening of an amorphous film, when the single crystalline film is made of the same kind of material as the substrate (Tokunaga, col. 2, lines 28-34). To grow a single crystalline film made of a different material than the single crystalline substrate, Tokunaga discloses that it is necessary to form another nucleus film on the substrate or excite the opening to the substrate.

By contrast to Tokunaga's teachings, claim 1 recites growing the single crystalline film directly within an opening, made in the amorphous film, that is not excited by ion implantation. Claims 17 and 18 recite that the single crystalline substrate and

the single crystalline film grown directly thereon are different materials.

Regarding the statement in the Advisory Action that Nakamura discloses multiple deposition sources and therefore teaches the optimization features recited in claim 1, Applicant respectfully disagrees with this conclusion. Nakamura discloses that both of the disclosed molecular deposition sources provide similar performance. And as discussed in Applicant's Response, dated May 13, 2003, the claimed invention provides unexpected results when viewed in light of the teachings attributed to Nakamura.

Nakamura discloses in Fig. 2(a) that Ga molecular ray source 2 and Al molecular ray source 3 are disposed to direct their respective beams at rotatable substrate 1 with a 90° offset between them (Abstract, lines 7-9). The basis provided in the Final Rejection, dated February 13, 2003, for rejecting Applicant's claims implicitly relies on the proposition that Nakamura's Fig. 2(b) illustrates the epitaxial growth rate for molecular ray sources 2 and 3 as a function of the angle of incidence that their beams strike substrate 1 (Final Rejection, page 3, lines 9-12). Assuming, *arguendo*, that Fig. 2(b) does illustrate this proposed relationship, an examination of Figs. 2(a) and 2(b) reveals that molecular ray sources 2 and 3 provide similar epitaxial growth rates relative to the angle of incidence

for their beams. A discussion of how the illustrations of Figs. 2(a) and 2(b) support this conclusion, when viewed in light of the interpretation of Fig. 2(b) proposed in the Final Rejection, is provided below.

Curve A of Nakamura's Fig. 2(b) corresponds to a molecular ray source 2 that is disposed to provide a molecular beam directed perpendicularly to a longitudinal axis of substrate 1, when angle ⊙ has a value of zero. Curve B of Nakamura's Fig. 2(b) corresponds to molecular ray source 3 that is disposed to provide a molecular beam directed parallel to the longitudinal axis of substrate 1, when angle ⊙ has a value of zero.

When the beam of molecular ray source 2 strikes substrate 1 perpendicularly to its longitudinal axis, the epitaxial growth rate provided by this source reaches its peak value. This condition is indicated in Fig. 2(b) by the value for curve A at ⊙=0°. Similarly, molecular ray source 3 achieves its peak epitaxial growth rate when its beam strikes substrate 1 perpendicularly to its longitudinal axis. This condition is indicated in Fig. 2(b) by the value for curve B at ⊙=90°.

When the beam of molecular ray source 2 strikes substrate 1 parallel to the longitudinal axis of substrate 1, the epitaxial growth rate provided by this source reaches its lowest value. This condition is indicated in Fig. 2(b) by the value for curve A

at $\Theta=90°$. Similarly, molecular ray source 3 achieves its lowest epitaxial growth rate when its beam strikes substrate 1 parallel to the longitudinal axis of substrate 1. This condition is indicated in Fig. 2(b) by the value for curve B at $\Theta=0°$.

Both curves A and B illustrate a maximum epitaxial growth rate when the respective molecular ray source directs its beam perpendicularly to the longitudinal axis of substrate 1. As the angle of incidence for the beam of either source moves from a perpendicular angle to a parallel angle of incidence, the growth rate continuously decreases from a maximum rate to a minimum rate. Therefore, the multiple molecular ray sources provide similar epitaxial growth rates relative to their respective angles of incidence with substrate 1. Moreover, this conclusion follows regardless of the number of molecular ray sources used or their respective positioning relative to one another. Therefore, the conclusion stated in the Advisory Action - that Applicant's optimization argument does not hold because Nakamura discloses multiple source deposition - is not supported by the evidence. The optimization argument mentioned in the Advisory Action was provided in Applicant's Response of May 13, 2003, and is paraphrased below for convenience.

The Final Rejection states that Nakamura discloses a molecular ray method of performing epitaxy wherein the angle of

incidence between the substrate and the molecular beam can be optimized between zero and 90 degrees (Final Rejection, page 4, 2nd paragraph). Continuing, the Final Rejection proposes that it would have been obvious to combine the teachings of Nakamura with those of Tanaka and Tokunaga because optimizing the angle of incidence between the beam and the substrate surface during the lateral overgrowth would have anticipated results (Final Rejection, page 4, 4th paragraph).

However, Nakamura discloses in Figs. 1 and 2 that epitaxial growth is optimized when a molecular beam from source 2 strikes a substrate 6 at an angle perpendicular to its surface. Additionally, these figures illustrate that the rate of epitaxial growth decreases as the angle at which the molecular beam strikes the substrate surface decreases from 90 degrees to zero degrees.

By contrast to the teachings of Nakamura, Applicant's claimed method achieves an increasing amount of epitaxial lateral overgrowth as the angle at which the molecular beam strikes the substrate surface decreases from 90 degrees toward zero degrees. In an exemplary but non-limiting embodiment of Applicant's invention, illustrated by Figs. 1-3, the molecular beam particles 6-1 and 6-3 that impinge on amorphous film 2 are entirely reflected, or nearly so, with few if any of the particles being deposited on amorphous film 2 (Specification, page 3, lines 16-

19). The molecular beam particles 6-2 impinging on an exposed surface 1A of single crystalline substrate 1, through opening 3, are almost entirely deposited without any being reflected (Specification, page 3, lines 19-21).

Referring now to application Fig. 2, as particles 6-2 continue to be deposited in opening 3, the deposited single crystalline film 7 grows up and out of opening 3 such that its upper surface 7a is higher than the upper surface of the surrounding amorphous film 2 (Specification, page 3, lines 23-25). Also, side surface 7B of the deposited film 7 becomes exposed to the molecular beam.

With side surface 7B exposed, molecular beam particles 6-5 impinging on side surface 7B begin to deposit on single crystalline film 7 without being reflected (Specification, page 3, line 27, through page 4, line 3). As illustrated in Fig. 3, a lateral single crystalline film 9 grows laterally overtop of amorphous film 2 as the epitaxial growth continues on side surface 7B (Specification, page 4, lines 6-8).

As stated in the Final Rejection, Nakamura discloses optimizing the angle of incidence between the substrate and the molecular beam to positively affect the product (Final Rejection, page 4, 3rd paragraph). As illustrated in Figs. 1 and 2, Nakamura discloses that the product is increasingly positively

affected by reducing the angle between the molecular beam and an angle perpendicular to the substrate surface. Additionally, Nakamura discloses that the optimal positive effect on the product is achieved by directing the molecular beam perpendicular to the substrate's surface.

The epitaxial lateral overgrowth provided by Applicant's method of claim 1 is incapable of being achieved by a molecular beam directed perpendicularly to the substrate surface. This is because the molecular beam particles would be directed along an axis that is parallel to side surface 7B. Thus, the particles would never strike side surface 7B to produce the lateral epitaxial overgrowth of amorphous layer 2.

Combining the teachings of Nakamura with those of Tanaka and Tokunaga in the manner proposed in the Final Rejection for obtaining the optimal crystal would render the proposed method unsatisfactory for, if not entirely incapable of achieving, its intended purpose. If the proposed modification would render the prior art invention being modified unsuitable for its intended purpose, then there is no suggestion or motivation to make the proposed modification. See MPEP §2143.01, 1st paragraph of 5th major heading; see also *In re Gordon*, 733 F.2d 900,221 USPQ 1125 (Fed. Cir. 1984).

In short, Nakamura teaches away from the claimed feature of introducing atomic, molecular, or chemical beams onto the surface of a substrate at an incident angle of not more than 40 degrees with respect to the substrate surface. Instead of the claimed feature, Nakamura teaches that 90 degrees is the optimal angle for epitaxial growth. Proceeding contrary to accepted wisdom in the art is evidence of nonobviousness. See MPEP §2145(X)(D)(3); see also *In re Hedges*, 783 F.2d 1038, 228 USPQ 685 (Fed. Cir. 1986).

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura, either alone or in combination, fail to disclose or suggest all of the instant claimed features. Specifically, the combined references fail to provide the suggestion or motivation to introduce atomic, molecular, or chemical beams onto the surface of a substrate at an incident angle of not more than 40 degrees with respect to the substrate surface, as claimed by Applicant. Therefore, allowance of claim 1 and all claims dependent therefrom is warranted.

"Evidence that a compound is unexpectedly superior in one of a spectrum of common properties … can be enough to rebut a *prima facie* case of obviousness." *In re Chupp*, 816 F.2d 643, 646, 2 USPQ2d 1437, 1439 (Fed. Cir. 1987); MPEP §716.02(a), 1st paragraph of 2nd major heading.

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura fail to teach or suggest the benefits accruing from the instant claimed combination. Therefore, allowance of claim 1 and all claims dependent therefrom is warranted for this independent reason.

Dependent claim 17 recites introducing atomic, molecular, or chemical beams onto the surface of a single crystalline substrate to grow a single crystalline film on the exposed surface of the substrate. Additionally, claim 17 recites that the single crystalline substrate and single crystalline film are of different materials.

The Final Rejection states that Tanaka discloses growing single crystalline GaN on a single crystalline sapphire substrate using an epitaxial lateral overgrowth (ELO) technique (Final Rejection, page 5, 3rd paragraph). The Final Rejection acknowledges that Tanaka does not disclose molecular beam epitaxy (MBE) as the method of GaN semiconductor growth (Final Rejection, page 3, 3rd paragraph). Continuing, the Final Rejection states that Tokunaga discloses laterally overgrowing GaAs on an amorphous film (Final Rejection, page 3, 4th paragraph). Additionally, the Final Rejection states that Tokunaga suggests the equivalence of MBE and chemical vapor deposition (CVD) for the growth of epitaxial films (Final Rejection, page 3, 4th

paragraph). Based on this information, the Final Rejection proposes that it would have been obvious to combine the references because Tokunaga suggests an equivalent method of growing selective epitaxial nitride films upon amorphous masking layers (Final Rejection, page 3, 5th paragraph).

While Tokunaga may suggest the interchangeability of MBE and CVD in the process of forming "a thin film by photolithography of the prior art," Tokunaga does not suggest their interchangeability for epitaxially growing a single crystalline film of one material on a single crystalline substrate of a different material (see Tokunaga col. 1, lines 24-33, for the above quoted text). To the contrary, Tokunaga discloses that "selective deposition methods are known in which a monocrystal substrate is covered partially with an amorphous thin film, and the same material as the substrate is epitaxially grown only at the exposed portion of the monocrystal substrate" (col. 2, lines 13-17). "[T]hese selective deposition methods rely on growing selectively the monocrystal semiconductor of the same kind from the exposed surface of the monocrystal substrate" (emphasis added) (col. 2, lines 28-31). Therefore, Tokunaga teaches away from the claimed combination recited in claim 17. It is improper to combine references where the references teach away from their

combination. See MPEP §2145(X)(D)(2); see also *In re Grasselli*, 713 F.2d 731, 743 218 USPQ 769, 779 (Fed. Cir. 1983).

Claim 18 more definitely recites the features of: (1) forming the single crystalline film on the surface of the single crystalline substrate; and (2) forming the single crystalline substrate and the single crystalline film using different materials. This claim states that the single crystalline film and a surface layer of the single crystalline substrate, upon which the single crystalline film is formed, have different molecular structures.

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura, either alone or in combination, fail to disclose or suggest all of the features of claims 17 and 18. Specifically, the combined references fail to provide the suggestion or motivation to introduce atomic, molecular, or chemical beams onto the surface of a substrate to form a single crystalline film of a first material, or molecular structure, on the surface of a single crystalline substrate of a different material or molecular structure, as claimed by Applicant. Therefore, allowance of claims 17 and 18 and all claims dependent therefrom is warranted.

With regard to claims 20-23, the Final Rejection states that it would have been obvious to one of ordinary skill in the art to use GaAs as the single crystalline film and sapphire as the

single crystal substrate because sapphire or GaAs substrates were known by Tanaka for use in selective epitaxy of III-V semiconductors of which GaAs and GaN are well known examples (Final Rejection, page 5, last paragraph). This is the only basis provided by the Final Rejection in support of the rejections of claims 20-23.

In rejecting claims for want of novelty or for obviousness, the examiner must cite the best references at his or her command. When a reference is complex or shows or describes inventions other than that claimed by the applicant, the particular part relied on by the examiner must be designated as nearly as possible. 37 CFR §1.104(c)(2).

A brief inspection of Tanaka's 34-column specification and nineteen sheets of drawings provides overwhelming support for a conclusion that this reference is extremely complex. The Final Rejection does not cite any particular part of Tanaka in support of the obviousness rejections of claims 20-23. Therefore, the evidentiary record fails to adequately support a *prima facie* case of obviousness.

Moreover, regardless of whether GaAs and GaN are well known examples of III-V epitaxial semiconductor films and whether sapphire or GaAs substrates were known to Tanaka, these statements alone fail to suggest the claimed combination. Tanaka

fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaAs, $Ga_{1-x}Al_xAs$, ZnSe, ZnS, CdTe, $ZnS_{1-x}Se_x$, or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, $SrTiO_3$, or sapphire and (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, as recited by claim 20.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaN, GaAs, $Ga_{1-x}Al_xAs$, ZnSe, ZnS, CdTe, $ZnS_{1-x}Se_x$, or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, or $SrTiO_3$ and (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, as recited by claim 21.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaAs, $Ga_{1-x}Al_xAs$, ZnSe, ZnS, CdTe, $ZnS_{1-x}Se_x$, or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, $SrTiO_3$, or sapphire, (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, and (3) forming a single crystalline film of a first molecular structure on the surface of a single crystalline substrate of a different molecular structure, as recited by claim 22.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaN, GaAs, $Ga_{1-x}Al_xAs$, ZnSe, ZnS, CdTe, $ZnS_{1-x}Se_x$, or YBCO onto the surface of a substrate of

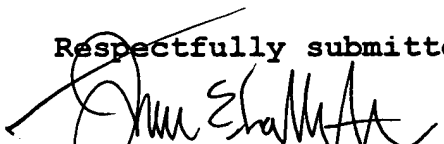
Si, GaAs, ZnSe, or $SrTiO_3$, (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, and (3) forming a single crystalline film of a first molecular structure on the surface of a single crystalline substrate of a different molecular structure, as recited by claim 23.

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura, either alone or in combination, fail to disclose or suggest all of the features of instant claims 20-23. Furthermore, Applicant submits that the evidentiary record fails to support a *prima facie* case of obviousness regarding these claims. Therefore, allowance of claims 20-23 is warranted.

In view of the above, it is submitted that this application is in condition for allowance and a notice to that effect is respectfully solicited.

If any issues remain which may best be resolved through a telephone communication, the Examiner is requested to telephone the undersigned at the local Washington, D.C. telephone number listed below.

Respectfully submitted,



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